A User-centred Design and Feasibility Analysis of the WiGlove - A Home-based Rehabilitation Device for Hand and Wrist Therapy after Stroke

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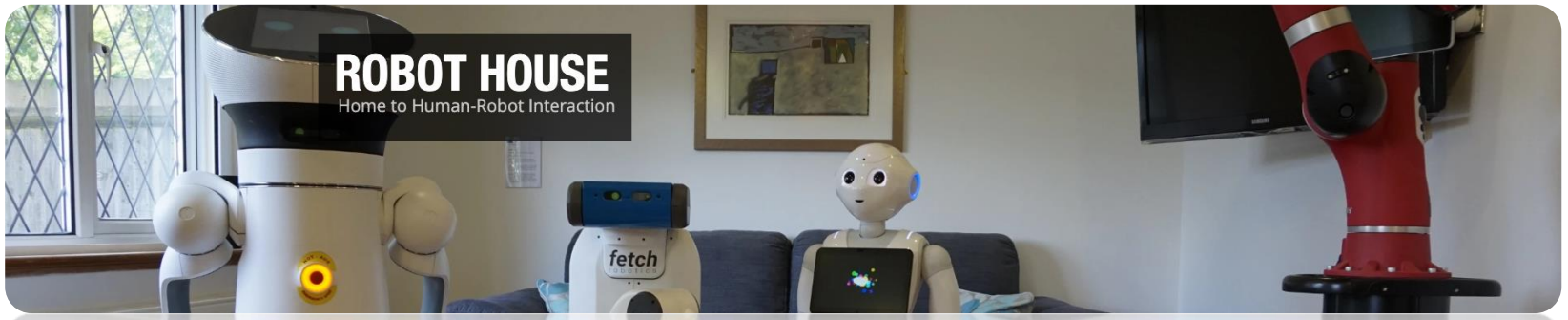
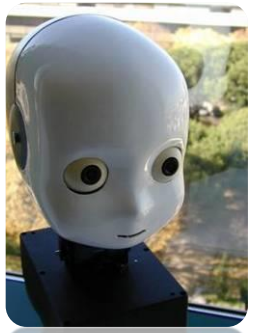
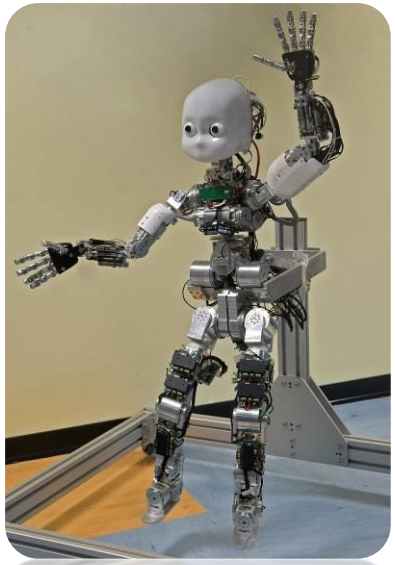
Vignesh Velmurugan is currently a PhD researcher at the University of Hertfordshire, UK. He received his masters degree in Advanced Robotics from the Ecole Centrale de Nantes, France and the Warsaw University of Technology. He has a bachelors degree in Mechanical Engineering from the College of Engineering, Guindy, Anna University, India.

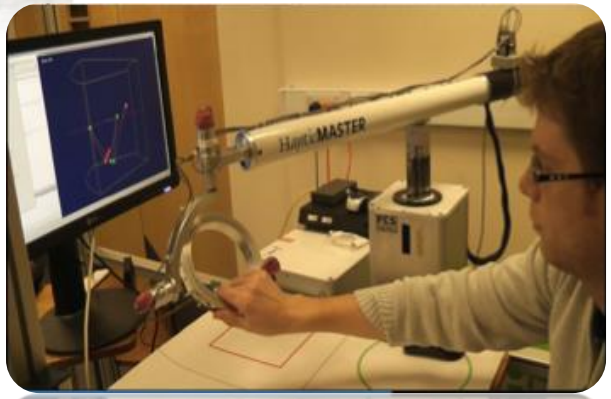
His current research focuses on rehabilitation robotics for post-stroke therapy. In addition, his interests include mechatronics, assistive robotics, human-centred design in healthcare robotics and human-robot interaction.



Robots in UH **Robot House** and Robotics Research Group

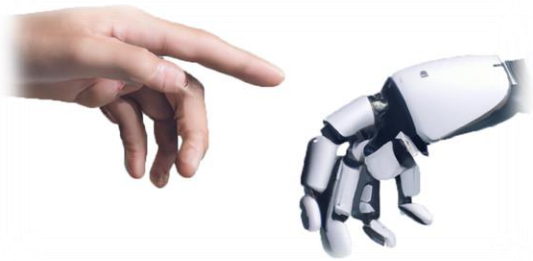






Introduction

Home-based rehabilitation



- Flexible training schedule.
- Less risky at times like COVID-19 pandemic.
- Requires:
  1. Remote monitoring.
  2. Means to assist with the training.
  3. Motivational interactions.

Robot-assisted therapy (RAT)

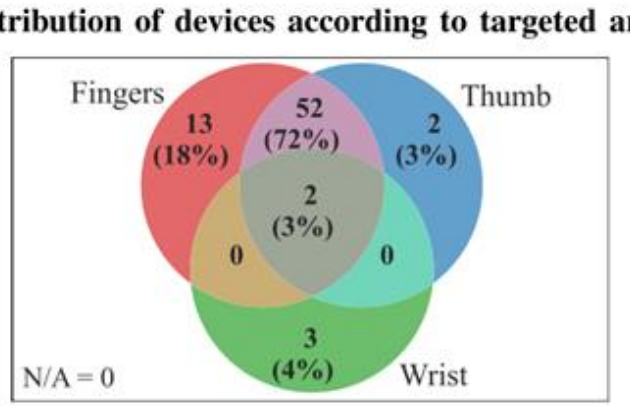
MIT-Manus

- High repetitions.
- Objective assessment measures.
- Games for motivation.

Background

- Hand impairments a major issue impacting ADL activities.
- Assistance with extension is often needed.

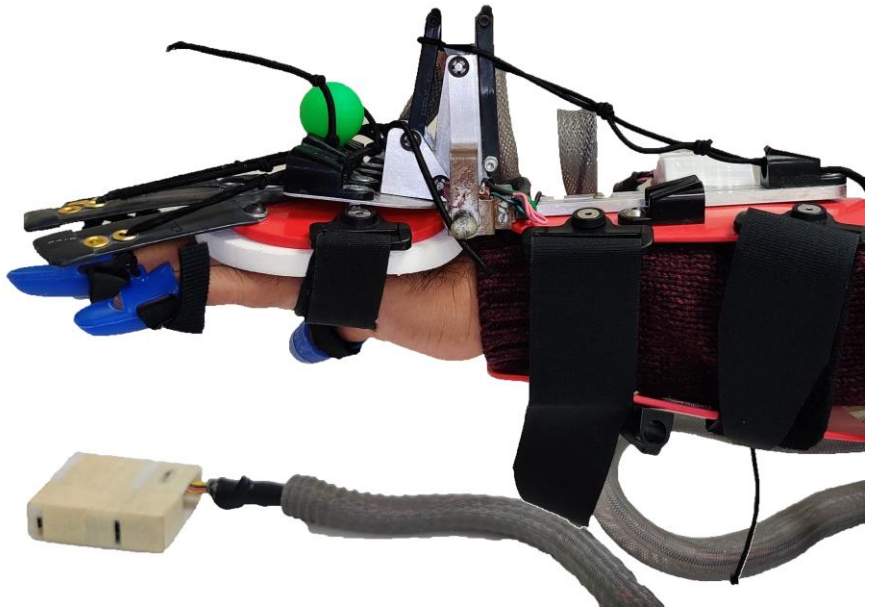
Hyperflexion of Wrist and Fingers (Yap *et al.*, 2016)



B.Noronha *et al.*, (2021)

State-of-the-art

- SCRIPT Passive Orthosis (SPO) passed its proof of concept.
- It had some Functional and Usability Limitations.
  - Research Gap and Opportunity to Innovate.



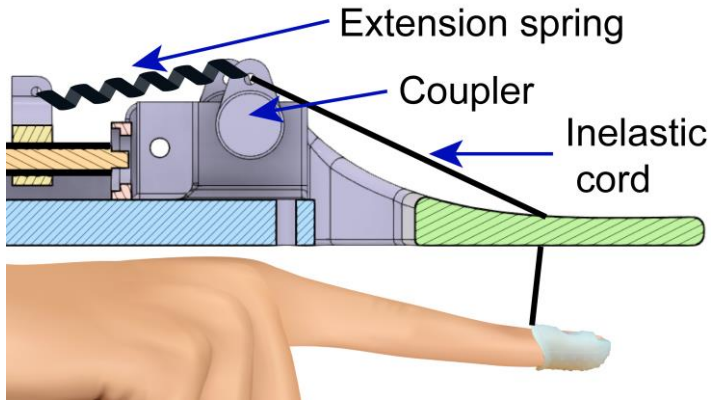
SCRIPT Passive Orthosis

Objective

- Design and develop, and evaluate the WiGlove.
- User-centred approach.
- Usability evaluations:
  - *Stroke therapists*
  - *Stroke patients*

The WiGlove

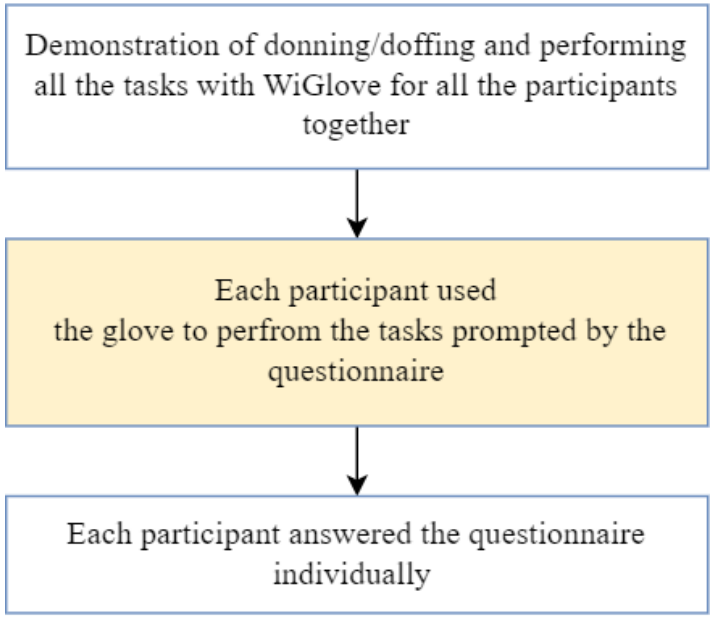
- Passive assistance with extension.
- Motorized tension adjustment.
- Measurement of flexion/extension angles.
- Increased tactile feedback.
- Wireless operation.
- Does not block any natural degrees of freedom.



Formative evaluation with stroke therapists

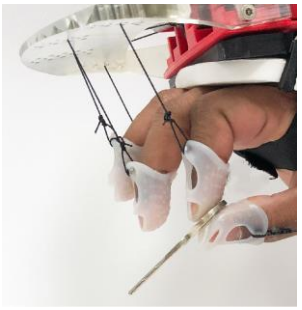
Study protocol

- Six stroke therapists.
- Tasks:
  - Donning/doffing.
  - Palmar pinch, cylindrical grasp and spherical grasp.
  - Played therapeutic games on the tablet.



Assessment measures

- 5-point Likert scale questions
- Open-ended questions



Palmar pinch

Cylindrical grasp

Spherical grasp

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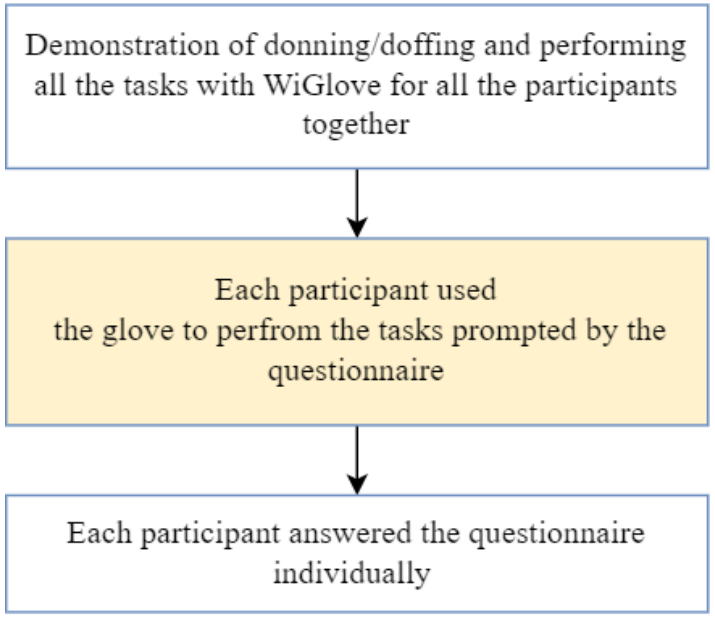

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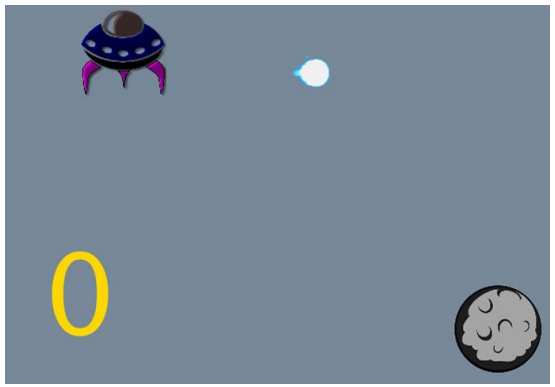

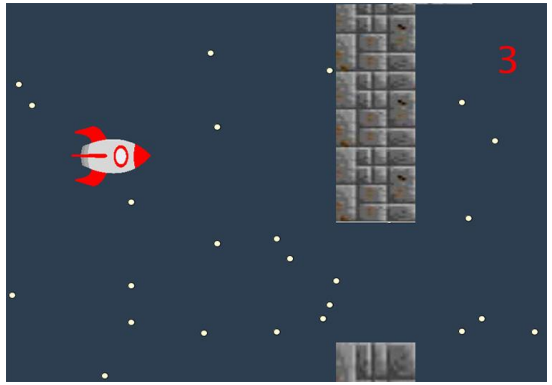

Results

- An overall the therapists positively rated the WiGlove's usability.

  "*Appears suitable for patients to do. However, would be limited to those cognitively able to do so*"

- Feedback used to identify areas for improvement.

  "*I found that the nuts of the glove were resisting my normal movement.*"

- Design revisions
  - Adjusted the position of the thumb's mechanism.
  - Modified the cushioning foam.

TABLE I. RESULTS OF THERAPISTS' FEEDBACK (1 - VERY DIFFICULT, 7 - VERY EASY)

	Median	Inter Quartile Range
Ease of donning the forearm module	4.5	1
Ease of donning the hand module	5	0.75
Ease of donning the fingercaps	5	1.5
Ease of doffing the forearm module	5	1.5
Ease of doffing the hand module	5	0.75
Ease of doffing the fingercaps	5	0.75
Ease of performing the ab/adduction of the wrist	4.5	2.5
Ease of performing the ab/adduction of the fingers	3.5	1
Perception of the weight	4.5	2
Ease of performing a palmar pinch (key grasp)	4	1.5
Ease of performing a cylindrical grasp(bottle)	6.5	1.75
Ease of performing a spherical grasp(ball)	5.5	1.75
Suitability for ADL	4	2
Aesthetic appeal	5	0.75
Perception of user safety	5	0.75
Perception of safety for the family	5	0

Home-based feasibility study

Study protocol

- 1 Hemiparetic stroke survivor
- 78 years old
- 15 months post-stroke
- Duration: 6 weeks
- At stroke survivor’s home
- Flexion/extension exercise (while performing ADL or playing games)

Image showing a stroke survivor's hand with hyperflexion in the fingers being offset by WiGlove.

Training while playing therapeutic games.

Assessment measures

- Box and Block Test
- Training data : Duration, range of motion, etc.
- Semi-structured interview
- QUEST 2.0 questionnaire (5-point Likert scale)

Results from the first three weeks

- Average training duration : 50 (42) minutes / day.
- Modified Box and Block test : Number of blocks picked and dropped in 60 seconds.

	At the Beginning of the study	After three weeks
While wearing the WiGlove	2	9

" *Felt very happy even when I hit just twice* "

" *How long will, I need, I don't know, but, Definitely, the glove makes a difference* "

- Positively rated the WiGlove's usability and suitability for home environment.
- QUEST 2.0 rating : 3.75 (*more or less satisfied* to *quite satisfied*).

" *It was not supple enough, but over the last two weeks, the mornings, it is very relaxed and soft* "

Conclusion

- The WiGlove's design was revised based on the therapists' feedback.
- Preliminary evidence supporting the revised prototype's feasibility to deliver effective rehabilitation.

Future Work

- Extension of the study with additional participants experiencing varying levels of motor impairments after stroke.

Thank you

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An earlier publication on the WiGlove's development can be found by scanning the QR code below: